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STUDY OF 150-KHZ FINITE AMPLITUDE PLANE WAVES REFLECTED FROM A --ETC(U)

JUN 68 D G BROWNING, R H MELLEN

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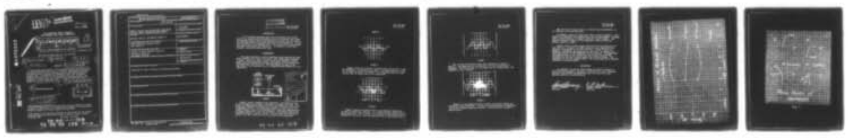

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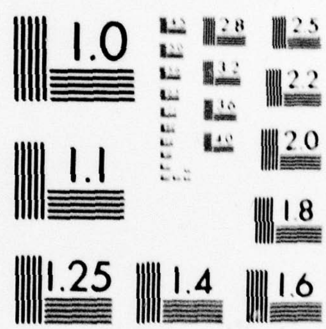
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STUDY OF 150-kHz FINITE AMPLITUDE PLANE WAVES REFLECTED FROM A PRESSURE-RELEASE SURFACE,[1]

1 SC

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10 David G. Browning ~~and~~ Robert H. Mellen

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11 7 June ~~1968~~

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ABSTRACT[2]

Time domain measurements of the pressure waveform are made for an initially sinusoidal plane wave as it becomes progressively distorted, is reflected from a pressure-release surface, and returns along the original path. As expected, the 180° phase shift upon reflection reverses the sense of the finite amplitude distortion; however, the asymmetry of the incident wave does not allow the reflected wave to return to a perfect sinusoidal form.

17 ZR0010101

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1 This memorandum consists of the abstract, text and slides of a paper presented by the authors at the Seventy-Fifth Meeting of the Acoustical Society of America in Ottawa, Canada on 24 May 1968.

2 This abstract was previously published in The Program of the Seventy-Fifth Meeting of the Acoustical Society of America, Ottawa, Canada, 21-24 May 1968.

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INTRODUCTION

If an initially sinusoidal plane finite amplitude wave travels until it is significantly distorted and then is reflected from a pressure-release surface, Lester and Breazeale have shown that the resulting 180° phase shift will reverse the sense of the distortion. As this wave continues it will progress back to the characteristic saw-toothed form that it had before the reflection. In doing so, it will pass through a relatively undistorted state.

EXPERIMENTAL

This paper describes a similar experiment which measured the time domain pressure wave forms from a 40cm x 40cm 150kHz plane transducer in water. By use of a small acoustic probe whose resonance is much higher than the fundamental frequency the details of the incident and reflected wave forms are shown. The measurements are made in the near field of the transducer and at a frequency where absorption is not significant.

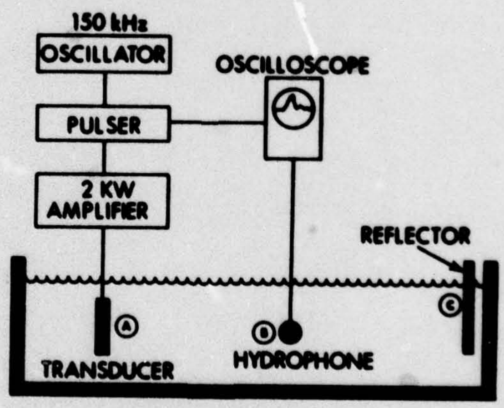

FIGURE 1

Figure 1 shows a diagram of the experiment. The pulses go both to the transducer and through a time delay to trigger the scope. The probe is a .8mm diameter Barium Titanate element mounted at the end of a hypodermic needle. The reflecting surface is a thin layer of air trapped between a sheet of polyethylene and a rigid flat backing which is located three meters from the transducer. The fresnel zone of the transducer extends to about 4 meters. The wave forms were observed at points A, B, and C which were all on the axis of the transducer.

RESULTS

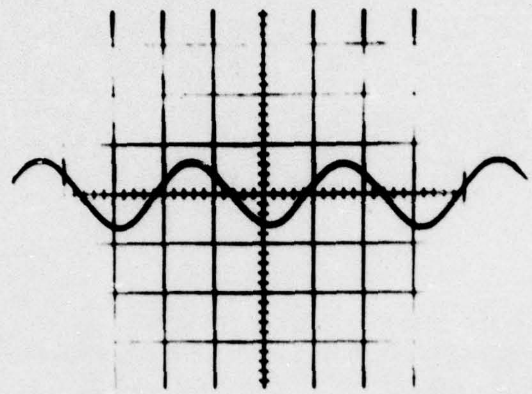

FIGURE 2

Figure 2 shows the initially sinusoidal wave form at point A near the transducer. The distortion is small. The peak pressure is 1 bar. All of these wave forms will appear to be travelling from your right to your left, of course, due to the scope sweep.

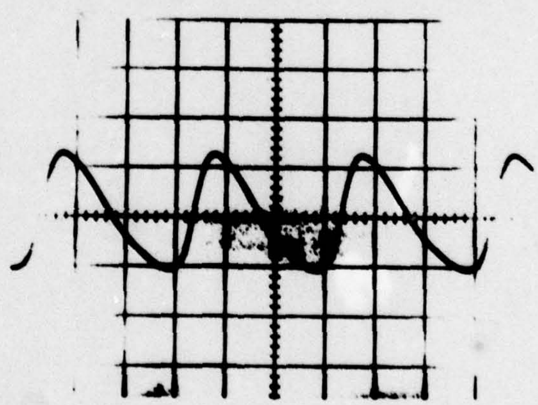

FIGURE 3

Figure 3 shows the waveform after it has traveled 3 meters and is about to strike the reflector. It is developing the characteristic saw-toothed form. Note, however, the increase in peak pressure and the asymmetry of the wave. Both are apparently due to near field effects.

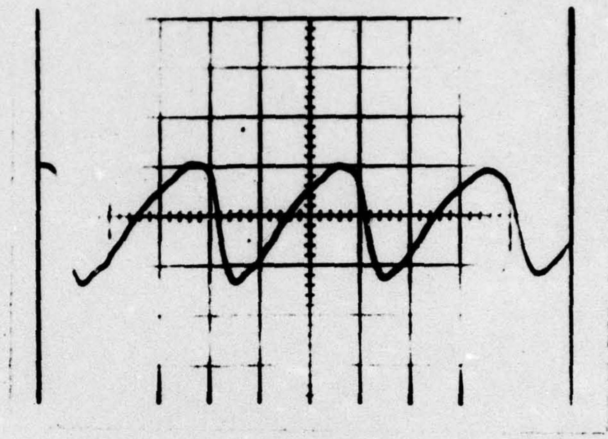

FIGURE 4

Next, we have the waveform right after reflection as shown in Figure 4. The phase shift is the expected 180° and the amplitude is unchanged. The trailing edge is now steeper than the leading edge. The asymmetry is still retained.

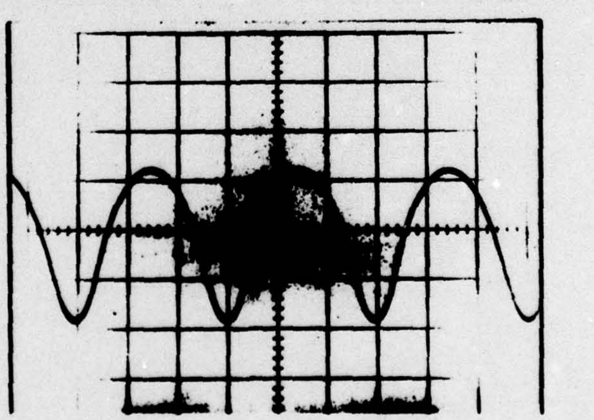

FIGURE 5

Figure 5 is the waveform at point B which is half-way between the reflector and the transducer. The wave has progressed back to symmetrical but not the original sinusoidal waveform. Note the further increase in peak pressure.

When the wave is back at point A, 3 meters from the reflector, it is returning to the saw-tooth form.

The harmonic content of these wave forms is shown in Figure 6. The dashed line represents data obtained from previous measurements. Although there is some variation, it appears there are no great changes. The harmonics decrease slightly as the fundamental rises and then the pattern returns to normal.

Figure 7 shows the phase angles associated with the harmonics for each wave form. Actually, the phase angles do vary slightly for the harmonics in waveforms in the first two cases, enough to cause the asymmetry, but are the same magnitude as our error. As expected, the reflected waveform is 180° different from the incident. It appears that the symmetry shown by the waveform half way between reflector and transducer was due more to phase change than harmonic content. The progression of the last waveform back to the saw-toothed form is somewhat reflected in the phase angles.

CONCLUSIONS

In conclusion, we can say that although the general features of plane wave theory appear to be valid in the field of a real transducer, the near field effects are significant must be considered in any detailed analysis of reflected waves.

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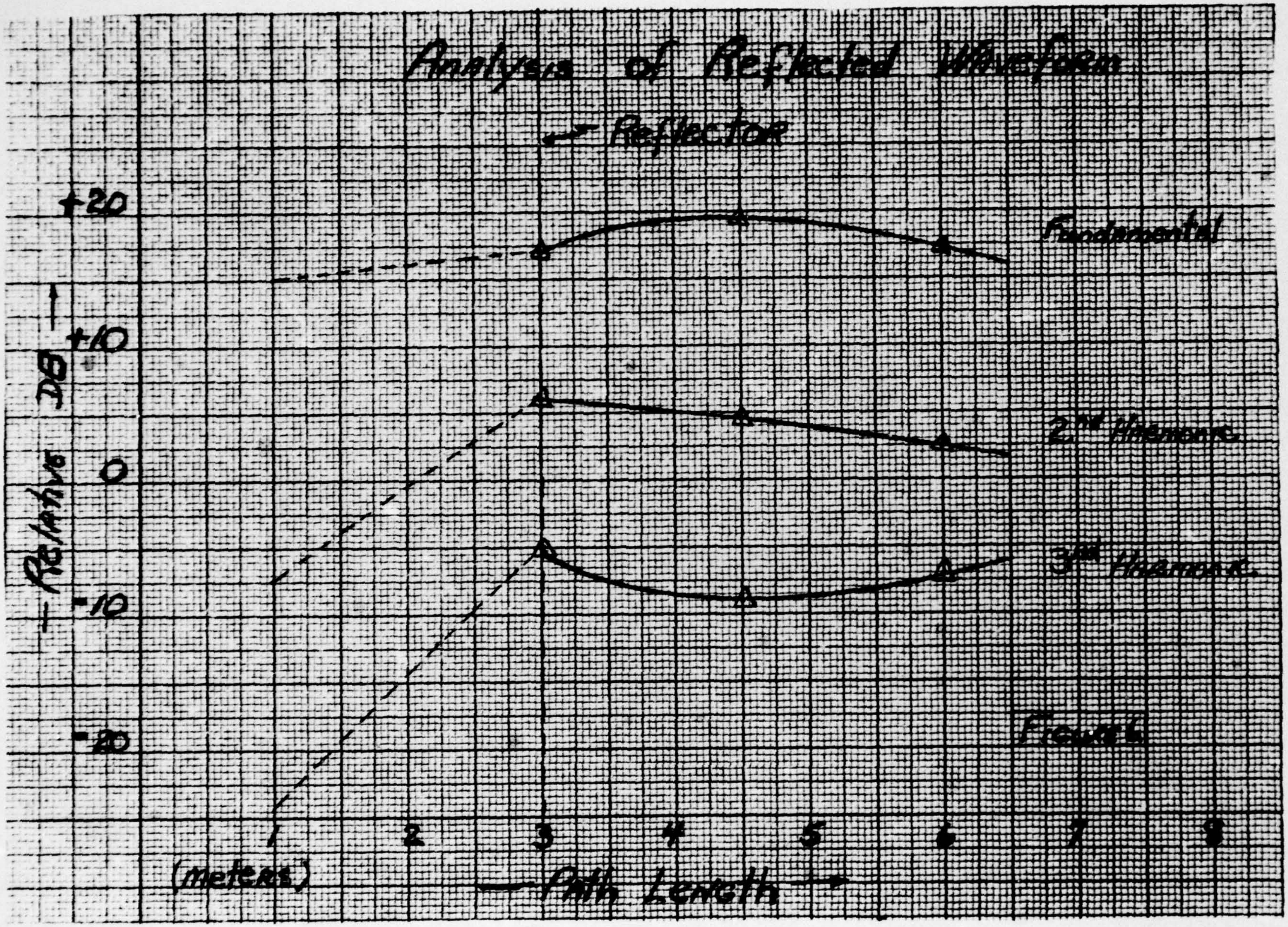
Analysis of Reflected Waveform
← Reflector
+20
+10
0
-10
-20
— Relative DB →
Fundamental
2nd Harmonic
3rd Harmonic
1
2
3
4
5
6
7
8
(meters)
— Path Length →

Figure 6

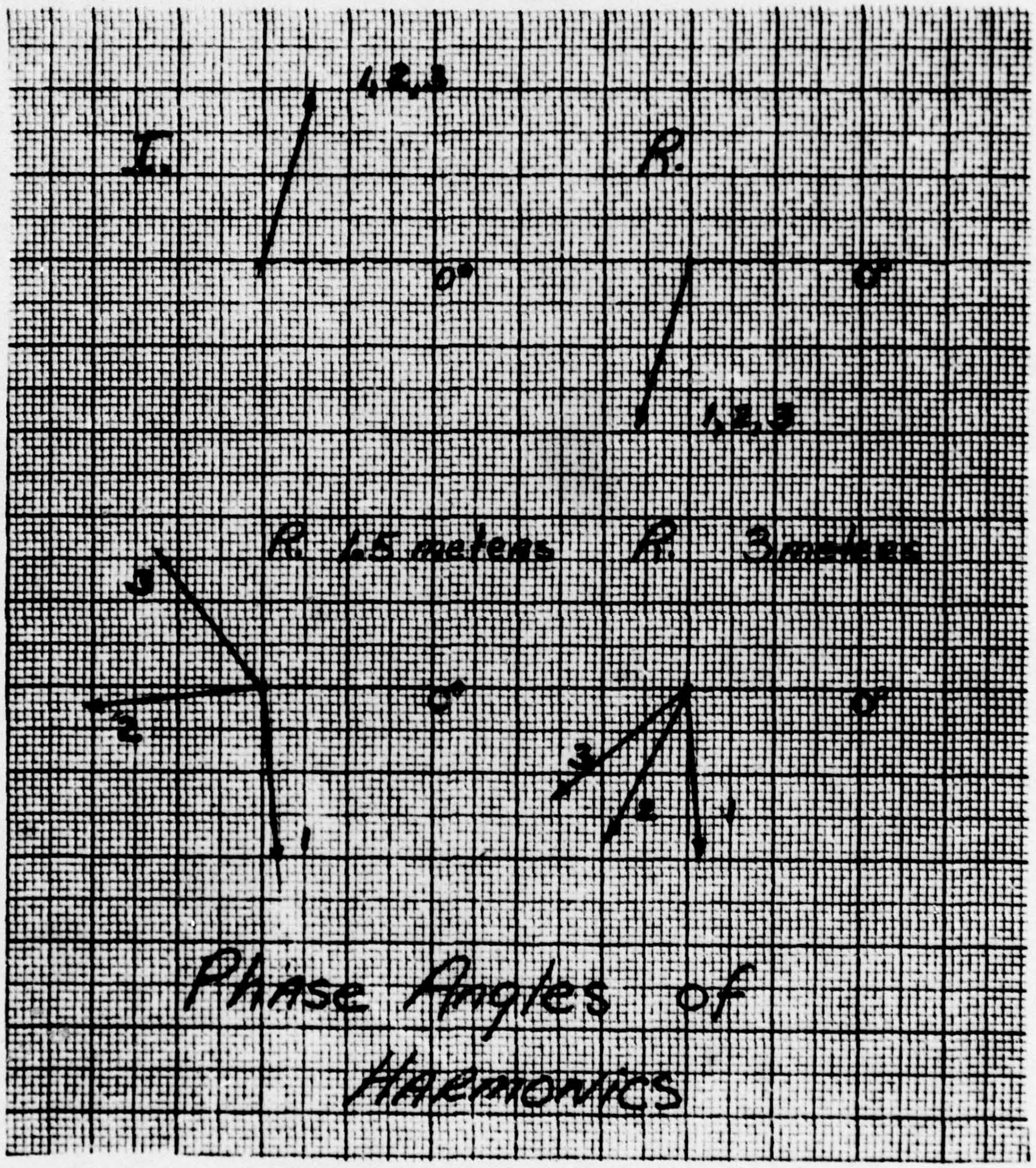
I.
1,2,3
0°
R.
0°
1,2,3
R. 1.5 meters
R. 3 meters
3
2
0°
1
3
2
1
0°
Phase Angles of
Harmonics

FIGURE 7.